the clothing, feeding and housing of men, women and children make up the entire round of life, so that for their use the world may have naturally seemed created. This is an ancient and charmingly child-like conception. But when we know something of the earth's complexity, of its wonderful inter-relations, of its long past and of the certain developments through which it will pass in the future, these false notions give place to much more correct perspectives. Man is indeed a member of the great, organic family, but he has his place in the series, just as do all the other members. He plays his part, but so do they. In some respects he is more impressive than other living creatures; in some respects less so. A well-balanced student of natural science accepts these facts and draws no comparisons of superiority or inferiority. He has borne in upon him the conviction that human affairs are not all of the universe, and that he should be neither unduly exalted nor cast down. A calm and steadfast habit of mind should be his and his studies should exercise this disciplinary influence upon him.

The American who has given the best expression to this influence of nature upon man is Bryant. Himself a keen lover of the woods, fields and mountains, he had further the great gift of describing in dignified and musical verse their effects upon him. In his "Forest Hymn" and again in "Thanatopsis" we find these influences beautifully set forth. The calm philosophy which places one apart from the small bickerings and petty things of life rings true in his lines, so that often the words go coursing through our thoughts when face to face with the sublime phenomena of nature.

Bryant, however, is not alone in giving utterance to these conceptions of life. Many and many a naturalist—to use again as I have several times already this old descriptive term for a student of nature—many a naturalist has felt the same and from time to time has set down in his pages the thoughts regarding a philosophy of life, which sprang for utterance while describing material phenomena. We have had within a few years a monumental work from a venerable and greatly beloved Austrian geologist, Eduard Suess. He has discussed the "Face of the Earth"; that is, he has passed in review the entire surface of the earth; its elevations and depressions; their connection with geological structure and time of production; their characters; relationships; systems; causes. He spreads before us a wonderful panorama and casts a flood of light upon its obscurities. But when he comes to his closing sentences he is reminded that his pages are to be read by men and women, and to have their influence upon human lives. Recognizing, therefore, the problems which have been solved and the many others which remain for the future, he sums up in the following words:

> In the face of these open questions, let us rejoice in the sunshine, the starry firmament and all the manifold diversity of the face of our earth, which has been produced by these very processes, recognizing at the same time to how great a degree life is controlled by the nature of the planet and its fortunes.

J. F. Kemp

Columbia University

OUR RADIUM RESOURCES[1]

The "wonders of radium," both fact and fable, have been treated so extensively in the scientific and public press that it is not my intention, nor is it at all necessary, to repeat them here. Rather it is my wish to-day to present to a body of men interested in the development of American mining the present commercial situation as regards radium and its ores, and to point

[1] Address to the sixteenth annual convention of the American Mining Congress, Philadelphia, October 20–24, 1913.

out, so far as I may, some of those future developments that already begin to be more or less distinctively visible.

A bulletin on the radium, uranium and vanadium situation, by R. B. Moore, physical chemist in charge of the Denver office of the Bureau of Mines, and K. L. Kithil, mineral technologist of the Bureau, will appear within a few weeks and will contain much detail of interest to the mining industry. Last April an advance statement, authorized by the director, regarding this bulletin, brought out particularly the fact that practically all of the carnotite ore mined in the world in 1912 was shipped abroad and that this country was furnishing annually nearly three times as much radium from its Colorado carnotite deposits as all the rest of the world put together. It was further pointed out that this material has been bought by European buyers at a price entirely incommensurate with its radium value and that efforts should be made to keep at home both the radium itself and the profits of its manufacture; also that too much stress could not be laid upon the extensive waste of valuable radium ore thrown on the dumps of mines and prospects—much of it under such conditions that it could never be recovered.

The publication of this statement has already resulted in an increase of at least 33 per cent. in the price of carnotite ore, and European buyers are awakening to the fact that they must pay to the American miner a price nearer the actual value of his ore. Also, a much lower grade of ore is now marketable, for whereas six months ago ore containing 2 per cent. uranium oxide was the lowest grade accepted by European buyers, agents of these buyers are now asking for and actually purchasing ore containing no more than half this content of uranium. Furthermore, the operators are taking more care in separating their low grade ore from the gangue and in protecting it from wind and weather. Moreover, old dumps are being sold and ore that a few months ago was thrown aside as valueless will be recovered from them.

In this paper I shall refer to other facts contained in this bulletin and shall mention some new developments having a direct bearing upon the American radium industry which have taken place since the manuscript was sent to the printer.

As is well known to all of you, the popular belief has been that the chief source of radium is the mineral pitchblende, especially that obtained from the mines now under the control of the Austrian government at Joachimenthal, Bohemia, and pitchblende is the richest and most eagerly sought uranium radium ore. Outside of the ore in Austria, the only pitchblende deposits of any size are those in Gilpin County, Colorado, from which some thirty tons, more or less, have been procured since the mineral became valuable as a source of radium. The Denver papers recently announced that these pitchblende-bearing mines have been acquired by Alfred I. du Pont, of Wilmington, Delaware, and it is greatly to be hoped that their exploitation under his direction will yield an increased supply of this valuable mineral. It is not, however, so generally recognized that the mineral carnotite, which, outside of the United States, occurs only in the Olray district of South Australia and in low-grade ores mixed with ilmenite as a calcium carnotite (communicated by W. F. Hillebrand) under the name of Tyuyamyunite, in Ferghana, Russian Turkestan, low-grade ore mixed with ilmenite, is by far the more important source of radium. From the most authentic sources it can be definitely stated that the Australian and Russian deposits do not compare in extent or richness with our own. The American carno-

tite is accordingly the largest source of radium at the present time, and at least four times as much radium was mined in America in the form of carnotite in 1912 as has been produced from Colorado pitchblende since it was first discovered in that state.

Outside of carnotite and pitchblende, the only known source of radium is the mineral autunite. The autunite deposits of Portugal have probably furnished a few milligrams to commerce, and from the Mt. Painter deposits in South Australia a few tons of autunite-bearing ores have been shipped to London.

American carnotite is found chiefly in Montrose and San Miguel counties, Colorado, and in Utah, northwest of these counties. The Utah deposits are at Green River, Table Mountain, Richardson, Fruita, Moab, and some sixteen miles southeast of Thompsons. The ores of these deposits are of a lower grade than those of the Paradox Valley, but they are nearer to the railroads and transportation costs are much less. The Green River deposits have apparently become regular producers. In Colorado, prospects have been opened at Coal Creek, fourteen miles north of Meeker, and at Skull Creek, sixty-five miles west of Meeker, but the richest of all American carnotite localities and, indeed, the richest known radium-bearing region in the world is that of the Paradox Valley, extending from Hydraulic on the north to the McIntyre district on the south.

Geologists are now in the field making a special study of these carnotite ores with special reference to their occurrence and origin, of which altogether too little is now known. In the Paradox region, the deposits seem to lie invariably just above the fine-grained La Plata sandstone. This rock is usually exposed high on the sides of the canyons, some of which are excelled in extent and in natural beauty by only the Grand Canyon itself. In a few instances, as at Long Park and Club Ranch, the deposits are only a few feet under the surface, the higher formations having been eroded; but for the main part, the stratum in which the carnotite occurs, when not entirely eroded, is deep below the surface of the mass. Accordingly prospecting is mainly carried on along the sides of the canyons, and where vanadium and uranium stains are seen upon the rock the prospector blasts his tunnel in the hope of developing a pocket of the ore. The fact that the ore occurs in pockets renders prospecting uncertain, and there appears to be no present hope of insuring a successful search for pockets that are not exposed, or do not happen to be near the surface. Although it is probable that many other pockets of carnotite occur at the same geologic horizon, their discovery, except where the ore-bearing stratum has been exposed by erosion, appears at present to be an almost hopeless task. The eroded sides of the canyons have been prospected again and again, but new claims are still being opened and are being sold by the prospector to the larger companies or operators who mine the ore. In such a sale the prospector and the purchaser both take a decided risk, for at present no method is used to determine the extent of the ore in the pocket other than the "prospector's hole."

As few of the prospectors of the west are acquainted with carnotite and pitchblende, the following description of the ores has been issued from the Denver office of the Bureau of Mines and is sent to all who make inquiry:

In reply to your letter for information concerning radium ores, the following facts may be of interest:

Radium is found with uranium minerals only. Wherever uranium exists, radium is also found in the mineral; and where there is no uranium, radium

has never been found. Uranium and therefore radium are found in this country in carnotite and its associated minerals, and in pitchblende. Carnotite is a lemon-yellow mineral, usually found in pockets of sandstone deposits. The mineral may be in the form of light yellow specks disseminated through the sandstone, or as yellow incrustations in the cracks of the sandstone; or may be more or less massive, associated with blue, black or brown vanadium ores.

Pitchblende is a hard, blue-black ore that looks something like magnetite, but is heavier. It is found in pockets and veins in igneous rocks. This mineral is not nearly as widely distributed as carnotite. Occasionally it is found associated with an orange mineral called gummite.

The best way to test these ores is to wrap, in the dark, a photographic plate in two thicknesses of black paper. On the paper lay a key and then, just above the key, suspend two or three ounces of the ore, and place the whole in a light-tight box. Pressure of the ore on the key and plate should be avoided. After three or four days, develop the plate in the ordinary way; and if the ore is appreciably radio-active, an image of the key will be found on the plate.

The U. S. Bureau of Mines, 502 Foster Building, Denver, Colorado, will be glad to receive any samples of ores giving promise of containing radium and associated rare minerals, as indicated by the test above described. Though it can not undertake to make chemical analyses or assays of such minerals for private parties, it will indicate the advisability of further examination.

The Colorado carnotite deposits were apparently first noted as far back as 1881, when Andrew J. Talbert mined some of the ore and sent it to Leadville, where it was reported as carrying $5 in gold per ton. This must have been an unusual ore, as the carnotite now found does not carry the precious metal. In 1896, Gordon Kimball and Thomas Logan sent specimens to the Smithsonian Institution, Washington, D. C., and were informed that the minerals contained uranium. Shortly thereafter they mined 10 tons of ore, shipped it to Denver, and sold it for $2,700 on account of its uranium content. Three years later, in 1899, Poulot and Voilleque collected and sent to France specimens which were examined by Friedel and Cumonge, who recognized the existence of a new mineral and named it "carnotite," in honor of M. Carnot, then President of the French Republic. In 1900 Poulet and Voilleque leased carnotite ores at Cashin in the Paradox Valley to extract the uranium. They shortly after completed a small mill in the McIntyre district, south of the Paradox, and in this project had the cooperation of Jas. McBride, a mining engineer of Burton, Mich. Their mill ran until 1902 and during that time produced 15,000 pounds of uranium oxide. The mill was started again in 1903 by the Western Refining Company, but ran only a year. Up to 1904 the mills appear to have been run wholly with the idea of obtaining the uranium and vanadium from the ore, for no radium was extracted. Shortly afterwards the Dolores Refining Company built a new mill a short distance from the old one, but after running for some years, this mill, too, shut down. In 1912 the American Rare Metals Company acquired the mill of the Dolores Refining Company and is now operating it, with the special purpose of obtaining radium from the ores. The first attempt to extract radium in this country appears to have been made by the Rare Metals Reduction Company, under the management of Stephen T. Lockwood, of Buffalo, N. Y. In September, 1900, Mr. Lockwood brought back from Richardson, Utah, samples of carnotite ore and in 1902 he published in the *Engineering and Mining Journal* of September 27 the first radiographic plate from products of American carnotite. In June, 1902, he received 500 pounds of specially picked high-grade ore from Richardson, Utah, and in May, 1903, as a result of experimental work on this ore, he incorporated what was probably the first American company to operate a plant to produce

radium as one of its products. In October, 1903, the first experimental plant was constructed and in April, 1904, the first 17-ton car of ore reached Buffalo from Richardson, Utah. The company obtained a fair percentage of extraction, but the ore proved to be too low grade and the Richardson deposits were abandoned. No radium in concentrated form was put upon the market, although barium sulphate concentrates were produced.

The General Vanadium Company, which, with the Radium Extraction Company, is a subsidiary of the International Vanadium Company of Liverpool, England, was formed in 1909 and began work in 1910, the same year that the Standard Chemical Company of Pittsburgh, Pa., entered the field. Since that time these two companies have been engaged in mining carnotite. The ores from the General Vanadium Company have been shipped almost entirely abroad, while the Standard Chemical Company has shipped several hundreds of tons of carnotite to its works at Canonsburg, Pa. While it was stated at the time of the advance announcement of the bulletin to be issued by the Bureau of Mines, that one American company had actively entered into the production of radium, no actual sale of American-produced radium could be authenticated. Since that time, however, the Standard Chemical Company has entered the American markets.

Besides the American Rare Metals Company and the Standard Chemical Company, a third company—the Radium Company of America, with mines near Green River, Utah—has undertaken the production of radium in its plant at Sellersville, Pa. There is, therefore, every reason to hope that more and more of our ores will be worked up at home.

Besides the companies already mentioned, a number of independent operators mine and ship carnotite from the Paradox region and for the main part send their ores to Hamburg. Among the more prominent of these may be mentioned:

T. V. Curren, Placerville, Colo.
W. L. Cummings, Placerville, Colo.
O. B. Wilsmarth, Montrose, Colo.
David Taylor, Salt Lake City, Utah.

The costs of mining, and especially of transportation, are an important factor in the marketing of carnotite. The Green River deposits have a distinct advantage over the Colorado deposits in this respect, as they are nearer the railroad, but, as their ores do not average so high in uranium, this advantage is more apparent than real. The present cost of mining, sorting and sacking in the Paradox apparently vary from about \$28 to \$40 per ton. To this must be added an \$18 to \$20 hauling charge to Placerville, and, in most instances, an additional charge for burros from the mines to points that can be reached by wagon. The freight rate from Placerville to Hamburg, via Galveston, is \$14.50 per ton so that the average cost at present to the miner laying down his ore at the European markets approximates \$70 per ton. The selling price varies with the uranium content, but is by no means proportional thereto, since a premium is always paid for rich ores. Very recently, however, a decided improvement has taken place and for 2 per cent. ore, the price is now around \$2.50 per pound for the contained uranium oxide, with an allowance of about 13 cents per pound for the vanadium oxide content, so that the 2 per cent. ore will now bring in Hamburg about \$95 per ton. One per cent. ore is now salable, but unless this ore is taken from the dump, so that the mining cost may be disregarded, it will scarcely bear transportation charges from the Paradox, although it is more than probable that it will be soon shipped regularly from the Utah field.

A price of $95 at Hamburg for 2 per cent. ore leaves a fair margin of profit to the miner, as mining profits go, but when it is considered that this price represents only a little over one tenth of the value of the radium content of the ore and that from this fraction of the value the American miner has to meet the outlay represented by the investment, by mining costs, transportation and assay costs and by losses in transit, it seems scarcely just that nearly nine tenths of the value should go to foreign manufacturers of radium, especially when the fact is considered that radium can be produced much more readily from carnotite than from pitchblende. There are two ways of reducing this difference between the actual value of the ore and the price that the miner receives. One is to hold our American ores for a higher price, and the second is to manufacture radium at home.

Large wastes are still taking place in the mining of carnotite, owing to the inability of the low-grade ores to bear transportation charges. As has already been pointed out, however, a distinct improvement in this respect has taken place within the last few months. The miners are beginning to realize the value of their old dumps and are attempting to save the low-grade, non-shipping ore in such ways as will render its marketing possible when prices advance. The Bureau of Mines has done everything it can to impress the necessity of this truest kind of conservation upon the mine operator.

In addition, there is prospect that most of the low-grade ores can be successfully concentrated by mechanical methods and experiments at the Denver office of the Bureau of Mines indicate that a concentration of four to one can be obtained. In this concentration, however, there are losses which could be prevented by chemical concentration, but at the present time it costs more to ship the necessary chemicals to the mines than it does to ship the ores to places where these chemicals can be cheaply obtained. It would appear, however, that mechanical concentration can save at least one half of the material that is now going to waste.

Although, until recently, the manufacture of radium has been carried on almost wholly in France and Germany, there appears to be no good reason why our American carnotite should not be treated at home. Carnotite is much more easily treated than pitchblende and the essential features of methods for its chemical treatment are well known, although much of the mechanical detail of operation has been kept secret. As the mechanical requirements, however, are those which any well-grounded chemical engineer should be able to solve, there seems to be no good reason why any of our carnotite ores should be shipped abroad, even at two or three times the present market price of the material. As before stated, the essential features of chemical methods of extracting radium from its ores are well known. As regards the principles involved, the methods have advanced little beyond the original method published by Debierne.

The methods for carnotite may be described best in the words of Soddy, in an extract from "The Chemistry of the Radio Elements," by Frederick Soddy, page 55, published in 1911 by Longmans, Green & Co.

The most important operations in the working up of radium-containing materials are the solution of the materials, consisting usually of insoluble sulphates and the separation of the halogen salts of the alkaline-earth group in a pure state, followed by their fractional crystallization. The first operation is usually effected by vigorous boiling with sodium carbonate solution, filtering and washing free from sulphate. This is the well-known reaction studied dynamically by Guldberg and Waage, whereby an equilibrium is attained be-

tween the two pairs of soluble and insoluble sulphates and carbonates. Naturally the greater the excess of sodium carbonate the larger the proportion of insoluble sulphate converted into insoluble carbonate. In this operation it is advisable not to wash at once with water, but with sodium carbonate solution until most of the sulphates are removed, as thereby the reconversion of the carbonates back into insoluble sulphates is largely prevented. In dealing with crude materials—for example, the radium-containing residues from pitchblende—it is often advantageous to precede this operation by a similar one, using a sodium hydrate solution containing a little carbonate, which dissolves part of the lead and silica present. The carbonates, washed free from sulphates, are treated with pure hydrochloric acid, which dissolves the alkaline-earths, including radium. From the solution the latter may be precipitated as sulphates by sulphuric acid and reconverted back into carbonates as before, or sometimes more conveniently they may be precipitated directly as chlorides by saturating the solution with hydrogen chloride. This is a very elegant method of great utility in the laboratory, for the most probable impurities, chlorides of lead, iron, calcium, etc., remain in solution and only the barium and radium chloride are precipitated, practically in the pure state, ready for fractionation.

The price of radium appears for some time to have been holding steady at about $120 per milligram of radium metal. This does not mean that the material is bought in the elementary condition, but that the radium chloride and radium bromide, which are on the market, are paid for on the basis of the metallic radium they contain. This method of payment is a distinct advance over the old method of paying the same price indiscriminately for the chloride or bromide. This price of $120 per milligram of the metal is equivalent to approximately $91,000 per gram of radium chloride ($RaCl_2$), or $70,000 per gram of anhydrous radium bromide ($RaBr_2$). Whether this price will rise, fall or remain stationary can not be predicted. There is no question that there is to be an increased radium production and that meso-thorium is also coming upon the markets in increasing quantity, but the uses of and demand for radium are apparently developing at an even greater rate. Furthermore, the supply of the material is limited and no large resources are in sight. Only one estimate has been published of the total quantity of radium in the Colorado carnotite deposits, and that was 900 grams. This estimate is at least five times as large as has been made by any employee of the Bureau of Mines, reckoning all known deposits in the whole American field, even including material too low grade to be marketable. Besides the radium, the uranium and the vanadium present in carnotite are available assets, and recent developments indicate that all the uranium produced will soon be readily sold, while it is well known that there is a ready market for vanadium for vanadium steel.

The value to the public of these deposits is, however, not to be measured in dollars and cents. The value of the radium output of America will never compare with that of several of our common metals. The total value of the radium in the world's output of radium ores in 1912 was little more than $1,000,000. Accordingly, the value must ever be reckoned in what it can accomplish for the public knowledge and the public weal. No certain prediction can be made of the ultimate value of radium, or of its possible applications to science or medicine, but enough has been done to show that radium is worthy of the fullest investigation by our highest scientific and medical authorities. Developments in its application to medicine are coming fast. The foreign medical press contains many apparently authentic reports of cures by its use. Interesting developments are also under way in America, and those who have had the largest personal experience in its use are most enthusiastic over its future application. The public may soon look to impor-

tant publications from leading American authorities, who have had real experience in radium therapy. It is to be greatly regretted that, owing to the high price of the material, only three or four American surgeons have, so far as the Bureau of Mines is informed, been able to use it in quantities sufficient for the drawing of decisive conclusions. In the progress of the future applications of radium to the curing of disease, nothing is more to be feared than its use in nostrums of every kind. The "wonders of radium" have been so extensively exploited in the public press that already the name is being employed as a psychological agent in advertisements of all kinds of materials, many of which contain no radium at all, or, if this element is indeed present, in such small quantities that no therapeutic value can be expected. As bearing on the need of further experiment, attention is called to the fact that the concentrated action of large quantities of radium may effect cures that have been impossible with the smaller amounts heretofore available to the medical profession. It is doubtful if there is at the present time in the hands of the medical profession of America more than a single gram of this rare element, and the results of investigations soon to be published will show that the concentrated action of the gamma rays from several hundred milligrams arrest certain forms of cancer and other malignant growths when smaller quantities are without beneficial effect. It is highly important that the medical profession should also have some guarantee of the material they purchase, even if it is purchased in small quantities, and I am glad to note that the U. S. Bureau of Standards is preparing to standardize radium preparations. As several frauds in the sale of radium have already been perpetrated upon American physicians, they should all require that the quality of the material purchased should be certified under conditions which prevent error.

In closing, I take pleasure in saying that I am authorized by the Director of the Bureau of Mines to announce that a cooperative agreement has been entered into with the newly organized National Radium Institute, whereby the Bureau obtains the opportunity of a scientific and technological study of the mining and concentrating of carnotite ores and of the most efficient methods of obtaining radium, vanadium and uranium therefrom, with a view to increased efficiency of production and the prevention of waste.

The National Radium Institute was recently incorporated with the following officers:

Howard A. Kelly, of Baltimore, President.

Curtis F. Burnam, of Baltimore, Vice-president.

Archibald Douglas, of New York, Secretary and Treasurer.

James Douglas, of New York, and E. J. Maloney, of Wilmington, as additional directors.

The institute has no connection with the mining of pitchblende, details of which recently appeared in the Denver papers. It has, however, obtained the right to mine 27 claims in the Paradox Valley region, among which are some of the best mines in this richest radium-bearing region of the world. Nearly 100 tons of high-grade carnotite have already been procured. Under the agreement with the Bureau of Mines, the technical operations of the mines and mill are to be guided by the scientific staff of the Bureau. Work will begin in an experimental plant to be erected in Colorado, using entirely new methods developed at the Denver office of the Bureau of Mines. Concentration experiments also will be conducted in the Paradox, probably at the Long Park

claims, and if successful will be applied to reducing the wastes that now take place. Within a year at most, the mill operations should make results certain and the extraction of ore and production of radium will then be continued on a larger scale. The separation of uranium and vanadium will also be studied, a contract having already been signed for all of these by-products that may be produced. All processes, details of apparatus and plant, and general information gained will be published for the benefit of the people.

The institute is supplied with sufficient funds to carry out its plans.

The institute has been formed for the special purpose of procuring enough radium to conduct extensive experiments in radium therapy with special reference to the curing of cancer. It also expects to carry on investigations regarding the physical characteristics and chemical effects of radium rays and hopes in time to be able to assist or perhaps even duplicate the effects of these rays by physical means.

Actual experience, especially of the institute's president, in the application of the 650 milligrams of radium and 100 milligrams of mesothorium already in his possession, have led him and his associates to believe that with larger supplies many of the variables that can not now be controlled may be fully correlated, and that radium may become the most effective agent for the treatment of cancer and certain other malignant diseases. Important results have already been obtained by using high concentration of the gamma rays of radium with the alpha rays entirely cut off and the beta rays largely eliminated. Hospital facilities in both Baltimore and New York are already supplied.

The activities of the institute are sure to be of benefit to the prospector and miner by providing a greater demand for his already rare ore; to the plant operator by developing methods and by creating a larger market for his product, and to the people by assisting, and possibly by succeeding, in controlling the most malignant of diseases. The radium produced is intended for the institute's own use and will consequently remain at home.

The Bureau of Mines is especially fortunate in the opportunity to cooperate in the technological features of the work of the institute.

Charles L. Parsons
Division of Mineral Technology,
Bureau of Mines

THE DECENNIAL OF THE DESERT LABORATORY

The tenth anniversary of the establishment of the Desert Laboratory was celebrated at Tucson, Arizona, September 20.

During the day demonstrations of researches in progress were made to visitors, including members of the International Phytogeographic Society, as follows:

10:30 A.M. Suite of Plants in Series of Environic Reactions. By Dr. D. T. MacDougal.

10:45 A.M. Professor W. L. Tower's Experiments on the Influence of Environic Factors in the Evolution of the Chrysomelid Beetles. By Mr. J. G. Sinclair.

11:00 A.M. Researches on Water Relations of Plants. By Professor B. E. Livingston, assisted by Mr. Pulling and Mr. Shive.

12:00 A.M. Certain Features of Correlation Between Climate and Vegetation in the Tucson Region. By Dr. Forrest Shreve.

12:30 A.M. Experimental Studies in the Root-habits of Desert Species. By Dr. W. A. Cannon.

2:00 P.M. Calorimetric Method of Determination of Leaf-temperatures. By Mrs. Edith B. Shreve.

2:15 P.M. Comparative Light Measurements and the Chemical Effects of Radiant Energy in Plant Processes. By Dr. H. A. Spoehr.

2:45 P.M. Exhibition of Progenies of Young Plants Affected by Ovarial Treatments. By Dr. D. T. MacDougal.

3:00 P.M. Water Balance of Desert Plants. By Dr. D. T. MacDougal.